EXPLORING ENERGY PATHWAYS FOR THE LOW-CARBON TRANSFORMATION IN INDIA – A MODEL-BASED ANALYSIS

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Overview

At the 2015 UN Climate Change Conference (COP 21) held in Paris, India ratified its Intended Nationally Determined Contributions (INDC), transitioning to a green and sustainable energy production and economy. With a total population of more than 1.3 billion (World Bank 2017b, 2017a) and emerging industry sectors, Indias energy roadmap will have a significant impact on the global low-carbon energy transition. Hence, it is crucial to design a wholistic energy pathway towards a low carbon energy transition until 2050 including power, heat, as well as transportation sectors.

Methods

For this purpose, GENeSYS-MOD (Löffler et al. 2017) is used. The linear cost-optimmizing model calculates an energy path based on geographic, demographic, and economic assumptions until 2050. Therefore, technology specific parameters were integrated, such as operational lifetimes, timeslices, efficiency and availability factors. To reduce complexity, India is segmented into ten sub-regions and a transition in five-year steps from 2015 to 2050 is simulated. To allow a deeper understanding of theoretical transition pathways, three scenarios are presented. The benchmark (100% RES scenario) aims at a power supply, based solely on renewable energy sources in 2050 and is restricted by a CO_2 budget. In contrast, the Limited Emissions Only (LEO) scenario sets a slightly higher CO_2 emissions budget, based on the 450-ppm scenario of the IEA, and allows conventional energy sources in 2050. The data base for the Business As Usual (BAU) scenario is taken from the new policies scenario by the IEA and follows a rather conservative path. Furthermore, endogenous grid simulation has been added to the existing model. In addition to model specific analyses, this research provides a profound foundation on the political framework and existing policies by integrating information from India's National Electricity Plan (GOI-Ministry of Power and CEA 2016a, 2016b).

Results

The model results show that a transition towards a low-carbon energy system in the power, heat, and transportation sectors until 2050 is both technically feasible and economically archievable. Throughout both scenarios, solar power will establish itself as the key energy source by 2050, given the model's underlying emission limits and restrictions (see Table 1).

Playing a significant role during the pathway to decarbonization, around 70% of India's 2050 power composition will be attributed to solar power, followed by wind generation (24%) and hydropower (5%). Concerning process (high) heat, India's heavy reliance on fossil energy carriers, such as coal and gas will slowly fade out in favor of biomass (around 50%) and power to heat (around 40%). India's low-temperature heat production is evenly divided between biomass, solar thermal and heat pump technologies in 2050. Looking at the transportation sectors, both passenger and freight slowly shift towards renewable technologies, such as hydrogen and electric based means of transit.

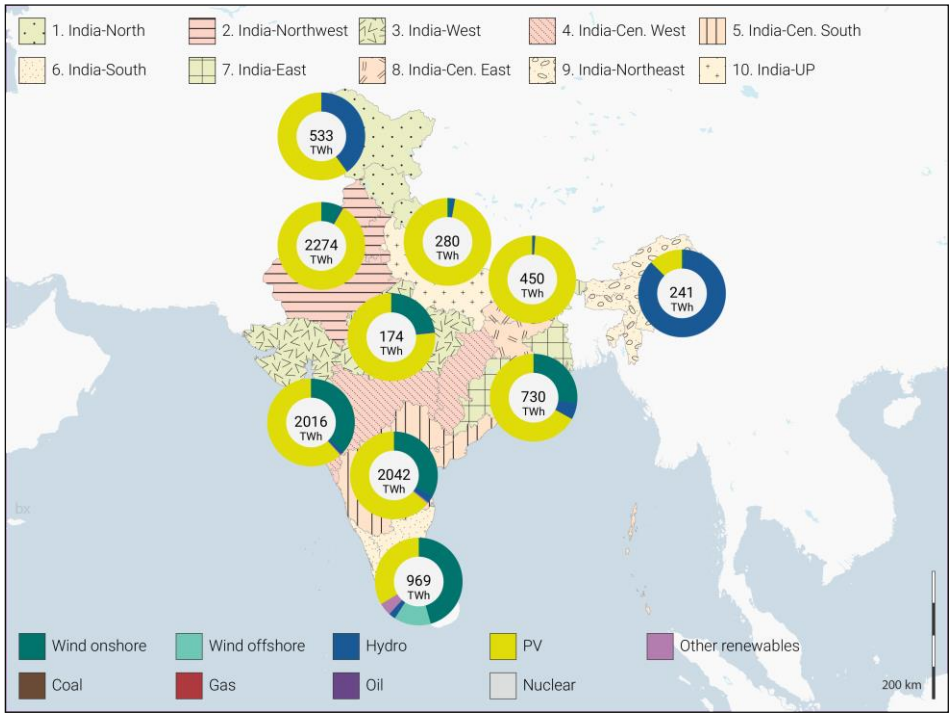

Figure 1: India's regional power production in the 100% RES scenario (2050)
Source: Own illustration.

Table 1: Comparison of India's power production in the three sceanrios (2050)

[TWh]	100%RES	LEO	BAU
Solar PV	8100	8005	5030
Onshore Wind	2739	2304	1946
Offshore Wind	122	0	31
Hydro	543	552	530
Other Renewables*	62	33	86
Nuclear	0	0	25
Coal	0	0	330

* *includes Geothermal, Wave and Tidal Energy.*
Source: Own calculations.

Conclusions

The biggest challenge for the renewable roadmap will be the lacking potential for renewable energies in metropolitan areas (e.g. Uttar Pradesh). To overcome those differences in RES potentials, there is an urgent need to expand the transmission grid and therefore reduce the existing transmission and distribution (T&D) losses. A decrease of current T&D losses of 19.425% down to 5% is regarded as realistic and obligatory to ensure an efficient usage of renewable sources.

References

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